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Reduced autobiographical memory specificity relates to weak resistance to proactive interference

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Abstract

Background and Objectives. Reduced autobiographical memory specificity (rAMS), experiencing intrusive memories, and rumination appear to be risk factors for depression and depressive relapse. The aim of the current study was to investigate whether a weak resistance to proactive interference (PI) might underlie this trio of cognitive risk factors. Resistance to PI refers to being able to ignore cognitive distracters that were previously relevant but became irrelevant for current task goals.

Method. Students ($N = 65$) and depressed patients ($N = 37$) completed tasks measuring resistance to PI and AMS, and completed questionnaires on intrusive memories and rumination.

Results. In both samples, weaker resistance to PI was associated with rAMS. There was no evidence for a relationship between resistance to PI and intrusive memories or rumination.

Limitations. As we did not assess other measures of executive functioning, we cannot conclude whether the observed relationship between rumination and PI is due to unique qualities of PI.

Conclusions. Difficulties to deliberately recall specific, rather than general or categoric autobiographical memories appear to be related to more general problems with the inhibition of interference of mental distracters. The results are in line with the executive control account of rAMS.

Key words: resistance to proactive interference; autobiographical memory specificity; intrusive memories; rumination; depression.

Reduced autobiographical memory specificity relates to weak resistance to proactive interference

1. Introduction

Depression is a highly prevalent psychological disorder with considerable relapse rates (see Richards, 2011, for a review). Knowledge about its risk factors is important with regard to early detection and prevention. Research has already pointed to some potential cognitive risk factors. To start with, depressed patients have difficulties to *intentionally* recall specific memories, that is, memories of a specific event that occurred at a specific day and did not last longer than 24 hours (Williams, 2006; Williams & Broadbent, 1986). This memory phenomenon is called *reduced autobiographical memory specificity* (rAMS) or *overgeneral memory*. Memory specificity is usually assessed with the Autobiographical Memory Test (AMT; Williams & Broadbent, 1986). In the AMT, participants are asked to recall specific memories in response to words (e.g., sad, brave, lonely, pride). Depressed patients tend to recall general or categoric memories such as “Whenever I get bad news” rather than specific memories such as “When my mother told me that my grandfather died”. Studies indicate that rAMS does not typically improve when patients are in remission (e.g., Mackinger, Pachinger, Leibetseder, & Fartacek, 2000; although see Wessel, Meeren, Peeters, Arntz, & Merckelbach, 2001). Moreover, rAMS negatively influences the course of depression in that it predicts higher prospective levels of depression, even when controlled for baseline symptomatology (e.g., Brittlebank, Scott, Williams, & Ferrier, 1993; Peeters, Wessel, Merckelbach, & Boon-Vermeeren, 2002; Raes et al., 2006; see Sumner, Griffith, & Mineka, 2010, for a meta-analysis). Researchers in this area agree that rAMS reflects a trait marker rather than an epiphenomenon of depression and as such may increase one’s vulnerability for developing depression and depressive relapse.

A second potential cognitive risk factor for depression is the occurrence of intrusive memories. *Intrusive memories* are spontaneous, repetitive, disturbing memories of negative autobiographical events. There is evidence that depressed patients experience more intrusive memories than controls (e.g., Patel et al., 2007). Moreover, longitudinal studies yielded evidence that such memories are predictive of prospective depressive symptoms, even after controlling for baseline symptoms (e.g., Brewin, Reynolds, & Tata, 1999; Newby & Moulds, 2011).

The final depression risk factor under consideration in this study is *rumination*, which refers to abstract, repetitive thinking about the meanings, causes, and consequences of current feelings or past experiences. People suffering from depression tend to ruminate more (Nolen-Hoeksma, 2004). Furthermore, depressed patients who ruminate more about their negative affect suffer from longer and more severe depressive episodes (see Lyubomirsky & Tkach, 2004, and Nolen-Hoeksma, 2004, and Watkins, 2008 for reviews). Not only depressive rumination, but also rumination about intrusive memories is related to depressive symptoms (e.g., Ehring, Frank, & Ehlers, 2008; Starr & Moulds, 2006; Williams & Moulds, 2007a, 2007b).

Taken together, rAMS, intrusive memories, and rumination each may put one at risk for depression or depressive relapse. Interestingly, there is evidence for the interrelatedness of these three variables as well. For example, research has shown that rAMS and intrusive memories often co-occur (e.g., Brewin, Watson, McCarthy, Hyman, & Dayson, 1998; Stokes, Dritschel, & Bekerian, 2004). Furthermore, experimentally induced rumination maintains rAMS, whereas control inductions (often a concrete, non-ruminative thinking style or distraction) increase AMS (e.g., Raes, Watkins, Williams, & Hermans, 2008; Watkins & Teasdale, 2001, 2004). Likewise, experimentally induced rumination leads to more intrusive memories than control conditions (e.g., Guastella & Moulds, 2007; Watkins, 2004).

Given that reduced autobiographical memory specificity, intrusive memories, and rumination are interrelated and that each may be a risk factor for depression, uncovering any shared mechanism seems to be of importance. One candidate for such a common factor may be resistance to proactive interference (PI). Resistance to PI is, like resistance to distracter interference and prepotent response inhibition, an inhibition-related function (Friedman & Miyake, 2004). Whereas prepotent response inhibition refers to the ability to inhibit dominant responses, resistance to distracter interference and resistance to PI are components of cognitive inhibition. Cognitive inhibition is the executive control capacity to supersede mental content, with executive control referring to the set of cognitive processes that are responsible for the planning, initiation, sequencing, and monitoring of complex goal-directed behavior in the face of distracting information (Dalgleish et al., 2007, p. 25). Note that cognitive inhibition seems to be impaired in depression (see Joormann & D'Avanzato, 2010, and Joormann, Yoon, & Zetsche, 2007, for overviews). Resistance to PI refers to the ability to ignore previously relevant but currently irrelevant, internal distractors, such as thoughts or memories. It seems unrelated to resistance to distracter interference and prepotent response inhibition (Friedman & Miyake, 2004). Both from a theoretical as from an empirical view, it seems that weak resistance to PI may underlie rAMS, intrusive memories, and rumination.

First, the executive control account of rAMS suggests that lowered executive functions, of which cognitive inhibition is a component, play a role in its etiology (Williams, 2006; also see Dalgleish et al., 2007). For example, irrelevant autobiographical knowledge should be ignored. This account was based on the Self-Memory System model (Conway & Pleydell-Pearce, 2000), an influential memory model. According to this Self-Memory System model, autobiographical memory consists of hierarchical layers of knowledge. The top layer would contain life time periods. Event-specific, experience-near knowledge would be represented in the bottom layer. General events would be in between. The idea is that there

would be constant patterns of activation within this hierarchical autobiographical memory base. When a pattern matches current goals, one can consciously experience a memory (Conway & Pleydell-Pearce, 2000). These patterns of activation can be generated in two ways. Conway and colleagues distinguish generative, voluntary, top-down memory retrieval on the one hand and direct, spontaneous, bottom-up memory retrieval on the other hand (Conway, 2005; Conway, Meares, & Standard, 2004; Conway & Pleydell-Pearce, 2000). The successful retrieval of a specific memory in response to an abstract AMT cue is assumed to be a product of an effortful top-down process. When confronted with a cue, intermediate representations will be activated, that is, memories referring to a summary of events such as “whenever people ignore me” (Conway, 2005). Activation then spreads through the autobiographical knowledge base to the bottom of the hierarchy, where more specific information is stored. Thus, general, categoric memories are relevant at first, but should be dismissed in the further search for a (more) specific, concrete memory. In this sense, responding with categoric memories in the AMT might be regarded as an instance of weak resistance to PI.

Second, ruminative thoughts, which are *by definition* difficult to disengage from (Koster, De Lissnyder, Derakhshan, & De Raedt, 2011), and intrusive memories may also be seen as instances of goal-irrelevant cognitions that should be ignored when engaging in task-relevant behaviour. Weak resistance to PI implies more difficulties to ignore such goal-irrelevant cognitions, and thus involuntary ruminations and intrusive memories would be more likely to surface.

Interestingly, there is some empirical evidence that cognitive inhibition, of which resistance to PI is a component (Friedman & Miyake, 2004), is related to rAMS (Raes, Verstraeten, Bijttebier, Vasey, & Dalgleish, 2010). More specifically, Raes et al. (2010) found that cognitive inhibition mediated the relationship between depressed mood and rAMS in

children. Furthermore, there is some evidence that resistance to PI may underlie intrusive memories and rumination. Laboratory studies have demonstrated that weaker resistance to PI predicts intrusive memories (e.g., Verwoerd, Wessel, de Jong, Nieuwenhuis, & Huntjens, 2011; Wessel, Overwijk, Verwoerd, & de Vrieze, 2008). That is, participants with a poorer pre-stressor ability to resist PI reported more intrusive memories of a trauma film 24 hours (Wessel et al., 2008) and in the week (Verwoerd et al., 2011) after the presentation of the film. Likewise, there is evidence that rumination is associated with an impairment in cognitive inhibition (e.g., De Lissnyder, Derakshan, De Raedt, & Koster, 2011; Joormann, 2006; Joormann & Gotlib, 2008, 2010; Whitmer & Banich, 2007). In addition, weaker resistance to PI seems to exacerbate the impact of rumination on negative affect (Pe et al., 2012).

Tasks of executive functions often tap more than one executive (sub)function (Friedman & Miyake, 2004, p. 102). Thus it seems that most studies in the literature on memory phenomena in depression focused on cognitive inhibition in general, rather than on one of its subfactors. The current study examined the associations of resistance to PI, one form of cognitive inhibition, with rAMS, intrusive memories, and rumination, three known risk factors for depression. To this end, we collected data in a non-clinical group as well as in a group of clinically depressed individuals. We hypothesized that weaker resistance to PI would be associated with rAMS, with more intrusive memories, and with higher levels of rumination (on depression and on intrusive memories).

2. Material and methods

2.1 Participants

2.1.1 Sample 1. Participants were 65 first-year psychology students (51 women) from the University of Leuven, who took part in the study in return for course credits. Their mean age was 19.28 years ($SD = 2.33$; range 18-34). This study was approved by the ethical

committee of the Faculty of Psychology and Educational Sciences, University of Leuven.

Written informed consent was obtained from all participants.

2.1.2 Sample 2. Participants were 52 inpatients (36 women), recruited at the psychiatric ward of the General Hospital Klinka (Brasschaat, Belgium). Patients whose main diagnosis was depression according to their psychiatrist, and whose Beck Depression Inventory score (BDI-II; Beck, Steer, & Brown, 1996) was 20 or more (indicating clinically significant symptomatology), were invited to take part in the study. Some of them also received a secondary diagnosis¹. We excluded ten patients from the analyses who did not meet the DSM-IV (American Psychiatric Association, 2000) criteria for current major depressive disorder according to the Major Depression Questionnaire (MDQ; Van der Does, Barnhofer, & Williams, 2003) at time of testing. Four patients who failed to finish the Proactive Interference task (see below), and one patient with manic symptoms were also excluded from the analyses. This resulted in a final sample of 37 patients (26 women)². Their mean age was 39.32 years ($SD = 12.26$; range 17-57). All patients were taking antidepressants³. Eight patients were clinically depressed for the first time. The remaining 29 patients had suffered recurrent episodes of depression. All participants were relatively well-educated. Three of them had finished high school, 26 had finished university college, and eight had finished university. This study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences, University of Leuven, and the ethical committee of the General Hospital Klinka. Written informed consent was obtained from all participants.

2.2 Materials

2.2.1 Proactive Interference task (PI-task). As an index of resistance to PI, we used the computerized paired associate (AB-AC) learning task described in Wessel et al. (2008; see also Rosen & Engle, 1998; Verwoerd, Wessel, & de Jong, 2009). Participants first learned twelve word pairs (A-B) consisting of strongly associated words, e.g., baker – bread, followed

by a first test phase. They then had to study twelve new word pairs (A-C) containing weakly associated words, e.g., baker – dough, followed by a second test phase. Before the two study phases, they were told to study the pairs in such a way that they could respond with the B-word (in the first test phase) or C-word (in the second test phase) when only the A-word was presented. Each word pair appeared for 2 s, after a 1 s presentation of a fixation cross. During the two test phases, the A-words appeared on the computer screen, and participants had to respond with the corresponding B-word (in the first test phase) or C-word (in the second test phase) as quickly as possible. They were instructed that reaction time mattered, and that answering quickly was more important than answering correctly. Each trial consisted of the presentation of a fixation cross (500 ms), an A-word (maximum 1 s), three dots (1 s), and then the correct word pair (2 s). They answered in a microphone connected to a voice key. The A-word disappeared as soon as the voice key picked up an answer. If no response had been given after 1 s had elapsed, the word disappeared and the participant heard a 250 ms tone in a headphone indicating that the answer-time was over. The experimenter used a response box for coding each response as correct, intrusion of a B-word (only in the second test phase, when the C-word had to be given), false, or microphone error. Trials were presented following a drop-out procedure. That is, the twelve A-words were first presented one time in a fixed random order, followed by a random presentation of the words until three correct responses were given. When this criterion was reached, the A-word was dropped from the list. When all the A-words were correctly answered three times, the total list was presented once again in a fixed random order. The number of trials needed to reach the criterion in the second test phase (i.e., the A-C word list; PI List 2) was used as index of PI in all analyses, always with control for the number of trials needed to reach the criterion in the first test phase (i.e., the A-B word list; PI List 1). In that way, we controlled for individual differences in general learning abilities. Higher scores indicate more PI, or, in other words, weaker resistance to PI.

2.2.2 Autobiographical Memory Test (AMT; Williams & Broadbent, 1986).

Participants were asked to give a specific autobiographical memory in response to 18 abstract cue-words (nine positive, nine negative). Time limit was 60 s per memory. Before starting, participants were explained that a specific memory is a memory that refers to a specific event that happened one specific day, and that did not last longer than 24 h. Participants were told that the memory could be important or trivial and that it could have happened long time ago or in the recent past. They were also instructed that they were not allowed to mention an event from the past week, or to repeat an already mentioned memory. Responses were transcribed verbatim by the experimenter. When participants gave a non-specific memory, they were prompted to be more specific. Before the actual test started, participants received a training phase in which they had an unlimited amount of time to provide a specific answer for three cue-words. The experimenter coded each first response as specific (events lasting less than a day), categoric (repeated events), extended (events lasting longer than 1 day), semantic associates of the cue-word, and omissions (no response). A second independent rater scored 10% of the responses. This scoring procedure obtained good reliability. For the student sample, inter-rater agreement was 97%, $\kappa = .94$. In the patient sample, inter-rater agreement was 86.1%, $\kappa = .76$. We used the number of specific memories, the number of categoric memories, the proportion of specific memories, and the proportion of categoric memories in our analyses⁴. The proportions were calculated by dividing the number of specific or categoric memories by the total amount of memories given. Omissions were thus ignored in proportional denominators of AMS.

2.2.3 Major Depression Questionnaire (MDQ; Van der Does et al., 2003).

MDQ is a self-report questionnaire for depression. Participants first answer the questions “In the last month, has there been a period of at least 2 weeks when you were feeling sad almost continuously?” and “In the last month, has there been a period of at least 2 weeks when you

lost all interest, or did not enjoy things that you usually enjoy?” If the answer to one of these questions is yes, participants indicate for 11 symptoms whether they experienced them during that same period. They also rate whether this had an impact on their work, on taking care of things at home, or on their social interactions. For scoring, the DSM-IV (American Psychiatric Association, 2000) diagnostic criteria are used, leading to the label ‘currently depressed’ or ‘not currently depressed’. The MDQ is highly consistent with SCID-based diagnoses (see Williams, Van der Does, Barnhofer, Crane, & Segal, 2008).

2.2.4 Beck Depression Inventory – second edition (BDI-II; Beck et al., 1996). The BDI-II is a self-report questionnaire assessing levels of depressive symptoms. It consists of 21 items, each including four statements. For each item, the respondent marks the statement that best describes how he or she felt during the past 2 weeks. We used the Dutch version by van der Does (2002). Cronbach’s alpha in the student sample was .88.

2.2.5 Ruminative Response Scale (RRS; Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The RRS is a self-report scale that measures the tendency to ruminate when feeling sad, down, or depressed. For the present purpose, we used a brief version, consisting of the items comprising the brooding and reflective pondering subscales only (Treynor et al., 2003; see also Schoofs, Hermans, & Raes, 2010) taken from the Dutch RRS (Raes & Hermans, 2007; Raes et al., 2009). These subscales contain 5 items each. Examples of items are ‘Go someplace alone to think about your feelings’ and ‘Why do I always react this way?’ Responses were scored on a 4-point Likert scale, from *almost never* (1) to *almost always* (4). A total sum score (range 1 – 40) was used in our analyses. Cronbach’s alpha was .72 for the student sample and .61 for the patient sample. A recent study showed that the distinction between brooding and reflection is blurred in currently depressed individuals, as two items from the reflection subscale cross-loaded on both the brooding and the reflection factor. Following the considerations of Whitmer and Gotlib (2011), we used the sum score of all ten

RRS items. In addition, we also investigated the brooding subscale, which is considered the more dysfunctional form of rumination (Treynor et al., 2003).

2.2.6 Responses to Intrusions Questionnaire (RIQ; Clohessy & Ehlers, 1999). The RIQ assesses intrusive memory frequency, the level of distress accompanying these intrusive memories, the meaning attributed to them, and the extent to which participants use dissociation, rumination, and suppression strategies to control their intrusive memories. The Rumination subscale (RRIQ) and the Negative Interpretations subscale (NI-RIQ) were used. The Rumination subscale contains 8 items, asking what participants did when memories of the traumatic event popped into their mind in the past week. We used the Dutch version of Ehring (2008), but we made two adaptations: We replaced ‘traumatic event’ with ‘an interfering/negative event’, and we did not restrict the answers to the past week, but asked to indicate the answer that applied best ‘in general’. The participants were instructed to rate the items with the following question in mind: “What do you *normally* do when involuntary memories of a dramatic/negative personal experience or event suddenly pop into your mind?” Examples of items are ‘I think about how life would have been different if the event had not occurred’ or ‘I dwell on how the event could have been prevented’. Responses are scored on a 4-point Likert scale, from *never* (1) to *always* (4).

The Negative Interpretations subscale contains 6 items. Participants receive the instruction: “Below are thoughts that people can have *about such memories that involuntary pop into their mind*. To what extent do you agree with these statements? The fact that such involuntary memories pop into my mind, means that...” They have to rate their reaction on a 7-point scale ranging from 1 (*totally disagree*) to 7 (*totally agree*). Examples of items are ‘Something is wrong with me’ or ‘I am going crazy’. The Dutch version of Engelhard et al. (2002) was used. They removed one item of the original scale (‘I will not be able to do my job well’), because it addressed work-related PTSD. As for the current study, Cronbach’s alpha

was .74 for RRIQ in the student sample, .62 for RRIQ in the patient sample, .79 for NI-RIQ in the student sample, and .79 for NI-RIQ in the patient sample.

2.2.7 Intrusion Question. In order to assess the occurrence of intrusive memories, we asked the question: “Did you experience, in the past week, that memories of a dramatic/negative personal experience or event suddenly and involuntarily popped up into your mind?” Responses were dichotomous.

2.3 Procedure

In both studies, participants were tested individually. The PI-task and the AMT were administered first. Afterwards, the questionnaires were filled out. The students completed all questionnaires during the test moment. In the patient sample, the BDI-II was filled out beforehand, when the patients entered the hospital. This was on average 6 days before the test moment. We received the BDI-II sum scores from their psychiatrists. All other questionnaires were filled out at time of testing.

2.4 Data-analysis

The assumptions required for parametric testing were met. Pearson correlations were calculated to investigate the strengths of the relationships between the PI-data, the AMT-indices, rumination, and depressive symptoms. To control for general learning ability, all correlations with the number of trials needed to reach the criterion for List 1 at the PI-task (PI List 2) were partial correlations, controlling for the number of trials needed to reach the criterion for List 1 at the PI-task (PI List 1). The significance test for Pearson correlations is parametric and requires at least one of the two variables to be distributed normally (Sedgwick, 2012). To search for deviations from normality, each variable was plotted as a histogram with a normal curve overlaid. Some data did indeed not follow a normal distribution. The AMT-indices and PI-data were not-normally distributed (although they were still close to normal). We further investigated whether we could do the significance test for the correlations

considering those variables. We first tried to transform the variables. A logarithm, square root, and multiplicative inverse transformation were done, but none of these transformations normalized the distribution of the data. We then created scatterplots with loess regression fit lines to search for nonlinear relationships. When these scatterplots indicated the possibility of a slight non-linear component to the relationship, we used polynomial regression to determine whether PI List 2-squared had an incremental effect beyond the linear effect. This was not the case. From this regression, we also examined the residuals to determine whether normality was a plausible assumption. We also plotted the standardized residuals as a function of the standardized fitted values to look for curvature and/or heteroscedasticity. We did not see any evidence that assumptions had been violated, so we believe it is safe to conclude that the relationship between resistance to proactive interference and memory specificity is linear and significant.

In order to test whether participants who experienced at least one intrusive memory in the week prior to the testing would show weaker resistance to PI than participants without intrusive memories, we conducted an ANCOVA on PI list 2 with the presence of intrusive memories (yes/no) as independent variable. To control for general learning abilities, PI list 1 was entered as a covariate in this analysis.

3. Results

Means and standard deviations for all variables can be found in Table 1, as well as the number of participants who reported to have had at least one intrusive memory in the week prior to testing. Tables 2 and 3 give an overview of the Pearson correlations⁵ between all variables in the student and patient samples, respectively. Of main interest are the associations between resistance to PI on the one hand, and rumination and AMS on the other hand. To account for general learning ability, we used partial correlations controlling for the number of List 1 trials (PI List 1) in all analyses involving the number of trials for List 2 (PI List 2).

Both in students and in patients, PI List 2 correlated with memory specificity. As predicted, the more trials participants needed to reach the criterion at List 2 of the PI-task (which is an indication of weaker resistance to PI), the fewer specific memories and the more categoric memories they recalled. However, PI List 2 did not correlate with depressive rumination (RRS total and RRS brooding) or rumination about intrusive memories (RRIQ and NI-RIQ).

We tested whether the significant correlations between PI List 2 and AMS would remain significant after also controlling for depressive symptoms (BDI-II scores). This was the case (see Table 4).

ANCOVAs (with dependent variable PI List 2, independent variable Intrusion Question and covariate PI List 1) were performed to test whether participants who experienced at least one intrusive memory in the week prior to the testing would show weaker resistance to PI than participants without intrusive memories. Results showed that this was not the case in the student sample, $F(1, 62) = 0.346, p = .558$ or the patient sample, $F(1, 34) = 1.380, p = .248$. Means and standard deviations for the PI-task performance of participants' with versus without intrusive memories can be found in Table 5.

4. Discussion

The present study investigated to what extent resistance to proactive interference (PI) is associated with three known (interrelated) risk factors for depression: reduced autobiographical memory specificity (rAMS), intrusive memories, and rumination. This was tested in students and in clinically depressed patients. The results were very similar for both groups. We observed a clear link between resistance to PI and AMS such that weaker performance on the PI task was associated with fewer specific personal memories in response to cue words. This was not due to shared associations with the level of depression. In other words, problems with intentionally recalling specific autobiographical memories seem to be

related to a relatively weak inhibition of previously relevant but currently goal-irrelevant information.

The finding that performance on the PI-task was related to rAMS is in line with the hypothesis that an executive control deficit is one underlying process of rAMS (Dalgleish et al., 2007; Williams et al., 2007). Up until now, it was not yet clear which aspect of executive control was important, but cognitive inhibition seemed to be a plausible candidate (see Raes et al., 2010). More specifically, we reasoned that resistance to PI might be involved since it refers to the ability to ignore information that was relevant to previous task goals, but are not relevant once task goals have shifted, and that general or categoric memories (while trying to retrieve a specific memory) may be interpreted as such. The idea is that the deliberate search for a specific memory is initiated at the level of general events in a hierarchically organized autobiographical memory knowledge base (Conway & Pleydell-Pearce, 2000). Activation then spreads downwards, to the level of specific event knowledge. General, categoric memories would thus be relevant early in the search process, but become redundant later on. Our finding that rAMS relates to a weaker resistance to interference of previously relevant but currently irrelevant information fits in with these theories of autobiographical memory retrieval that underscore the role of executive functions in rAMS (i.e., the theories of Conway & Pleydell-Pearce, 2000; and Williams et al., 2007). The current finding extends previous findings of an association between impaired executive control and rAMS (e.g., Dalgleish et al., 2007) by focusing on one particular executive control function, that is, weak resistance to proactive interference. Our findings suggest that this component might be of importance.

Note that in the student sample, the number of trials at List 2 of the PI-task correlated significantly with the proportion of specific memories, but not with the number of specific memories. The difference between the number and the proportion of specific memories lies in the role of omissions, as omissions are ignored in the proportional denominators of AMS. We

have no ready explanation for these findings. But in non-clinical individuals, it is not unusual that findings with the autobiographical memory test (AMT) are inconsistent (see Raes, Hermans, Williams, & Eelen, 2007). We suggest that researchers who use the AMT in non-clinical samples always report both the number and the proportion of specific and categoric memories.

Contrary to predictions, we did not find evidence for an association between resistance to PI and intrusive memories. These findings do not confirm results of previous studies (Verwoerd et al., 2011; Wessel et al., 2008). Note that the earlier prospective work consisted of laboratory studies using a trauma film for eliciting intrusive memories. In such a set up, all participants experience an event that might give rise to intrusive memories, maximizing the likelihood of detecting the protective effects of an individual differences variable such as resistance to PI. By contrast, the current study focused on naturally occurring intrusive memories. Apart from individual differences, the occurrence of these memories would depend on whether there was a precipitating stressor. If people did not experience a serious event, they would not report intrusive memories, yet they might perform poorly on a resistance to PI task. In addition, the absence of a link between PI and intrusive memories in the present study may be due to low sensitivity of our intrusive memory measure. Participants simply reported whether or not they had experienced intrusive memories in the past week. Future studies, relying on more participants with a history of stressful events and employing more sensitive measures might determine whether resistance to PI is indeed associated with naturally occurring intrusive memories (cf. Verwoerd et al., 2009).

The results also did not support our hypothesis that resistance to PI is related to rumination. We did not find any correlations between resistance to PI on the one hand, and depressive rumination, rumination about the content of intrusive memories, or rumination about experiencing intrusive memories on the other hand. One possible explanation may be

that our task to measure PI did not involve emotional stimuli. It might be that especially weaker inhibition of negative emotional material is associated with ruminative thoughts (see e.g., Joormann & Gotlib, 2008). Another explanation might be that the PI-task consists of concrete, highly or fairly imaginable words, whereas rumination is rather abstract in nature. It is possible that a relationship between PI and rumination can only or more easily be detected when using a PI-task with more abstract material. Yet, we should note that we did find an association between the PI-task and overgeneral memories, which are also rather abstract. A third explanation might be that state-rumination needs to be active in order to observe correlations between trait-rumination questionnaires and our behavioural PI measure. Possibly, current performance on the PI task is only associated with current, active rumination. However, it might be assumed that state-rumination was active in the depressed sample and the predicted association was also absent in that sample. Finally, it is possible that rumination is linked to yet another subfactor of cognitive inhibition than PI, such as resistance to distracter interference. This refers to the ability to resist interference of distracters in the external environment. For example, things as a disapproving facial expression or dust in the house might grab one's attention and launch ruminative thoughts about one's worthlessness.

Although the main focus of this study was on resistance to PI, other correlations deserve attention. First, although depression is generally related to *reduced* AMS (see Williams et al., 2007), we found that depressive symptoms were associated with more memory specificity in the student sample. However, such finding is not uncommon in studies with non-clinical participants (see Raes et al., 2007). Second, in contrast to what would be expected based on the literature (e.g., Ehring et al., 2008; Starr & Moulds, 2006; Williams & Moulds, 2007a, 2007b), we found a *negative* correlation between depressive symptoms and rumination about experiencing intrusive memories/negative interpretations about intrusive memories in the student sample. We currently do not have an obvious explanation for this

finding. But we find it interesting to note that similar to the association between depressive symptoms and AMS, the direction of the relationship between depressive symptoms and rumination is opposite to what is generally found in clinical samples, including the currently depressed sample in the present study⁶.

Some limitations should be noted. First, this study was correlational, which precludes making causal claims. From a theoretical point of view we assumed that the detected relationship between resistance to PI and AMS suggests that weak resistance to PI drives rAMS, rather than the other way around. That is, given the hierarchical model of autobiographical memory, it seems more plausible that having difficulties ignoring interference of irrelevant cognitions would lead to an incomplete intentional search for a specific memory, than the reverse. Yet, it cannot be excluded based on the present findings that the retrieval of categoric memories would (further) negatively impact resistance to PI. Future (experimental) research may determine the causal direction of the relation between PI and rAMS. Second, we have not assessed other measures of executive functioning. Hence, we cannot conclude whether the observed relationship between rumination and PI is due to unique qualities of PI or to shared qualities with other executive functions. Third, our samples sizes were relatively small. We calculated statistical power for the Pearson correlations for a medium effect size (.30), using G*power (Faul, Erdfelder, Lang, & Buchner, 2007). Power was .79 for the student sample and .57 for the patient sample. Future studies, relying on larger samples and employing various executive performance measures and/or various tasks measuring different forms of inhibition may shed light on whether resistance to PI indeed has specific predictive value.

To conclude, we aimed to acquire more knowledge about the underlying or related mechanisms of three known cognitive risk factors for depression. In particular, we focused on the relationship between resistance to PI on the one hand and rAMS, intrusive memories, and

rumination on the other hand. We found that weak resistance to PI was associated with rAMS in students as well as in a sample of clinically depressed patients. Weak resistance to PI was not related to intrusive memories, depressive rumination, and rumination about intrusive memories. The findings add to the growing body of evidence supporting the executive control account of rAMS (Dalgleish et al., 2007; Williams, 2006).

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Table 1. *Descriptive statistics for both samples.*

Variable of interest	Students <i>N</i> = 65		Patients <i>N</i> = 37	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
PI List 1	38.8	3.6	38.5	3.0
PI List 2	46.2	6.7	58.5	13.3
RRS (10)	22.9	5.2	27.1	4.8
RRS (B)	11.1	3.3	14.5	3.2
RRIQ	18.6	4.0	20.2	3.8
NI-RIQ	26.1	6.1	20.2	7.1
S	14.0	3.7	13.0	3.5
GC	0.5	1.0	2.4	2.7
pS	.86	.22	.76	.19
pGC	.03	.06	.13	.15
BDI-II	11.2	7.7	33.8	10.0
Intrusive memory in the past week	34 (52%)		27 (73%)	

Note. PI List 1 = Number of trials needed to reach the criterion at List 1 of the Proactive Interference task, PI List 2 = Number of trials needed to reach the criterion at List 2 of the Proactive Interference task, RRS (10) = Ten-item version of the Ruminative Response Scale, RRS (B) = Brooding subscale of the Ruminative Response Scale, RRIQ = Ruminative subscale of the Responses to Intrusions Questionnaire, NI-RIQ = Negative Interpretations subscale of the Responses to Intrusions Questionnaire, S = number of Specific memories at the AMT, GC = number of General, Categorical memories at the AMT, pS = proportion of Specific memories at the AMT, pGC = proportion of General, Categorical memories at the AMT, BDI-II = Beck Depression Inventory – Second edition.

Table 2. *Pearson correlations in the student sample (N = 65).*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. PI List 2 ^a	---	-.02	.06	.14	-.07	-.12	.30*	-.26*	.29*	-.06
2. RRS (10)		---	.82***	.59***	-.24	.15	-.11	.11	-.13	.32**
3. RRS (B)			---	.67***	-.36**	.16	-.13	.17	-.15	.35**
4. RRIQ				---	-.31*	.07	-.15	.04	-.16	.24
5. NI-RIQ					---	-.17	.13	-.13	.13	-.44***
6. S						---	-.19	.91***	-.20	.26*
7. GC							---	-.29	1.00***	-.12
8. pS								---	-.29*	.12
9. pGC									---	-.12
10. BDI-II										---

Note. PI List 2 = Number of trials needed to reach the criterion at List 2 of the Proactive Interference task, RRS (10) = Ten-item version of the Ruminative Response Scale, RRS (B) = Brooding subscale of the Ruminative Response Scale, RRIQ = Ruminative subscale of the Responses to Intrusions Questionnaire, NI-RIQ = Negative Interpretations subscale of the Responses to Intrusions Questionnaire, S = number of Specific memories at the AMT, GC = number of General, Categorical memories at the AMT, pS = proportion of Specific memories at the AMT, pGC = proportion of General, Categorical memories at the AMT, BDI-II = Beck Depression Inventory – Second edition.

^a All reported correlations with PI List 2 are partial correlations, controlled for PI List 1.

* $p < .05$, ** $p < .01$

Table 3. *Pearson correlations in the patient sample (N = 37).*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. PI List 2 ^a	---	-.30	-.14	-.26	.02	-.45**	.28	-.36*	.29	.00
2. RRS (10)		---	.74***	.52**	.29	.09	-.06	.10	-.05	.21
3. RRS (B)				.30	.47**	.13	.05	-.07	.06	.36*
4. RRIQ				---	.07	.28	-.21	.29	-.21	.39*
5. NI-RIQ					---	-.26	.24	-.27	.23	.42*
6. S						---	-.83***	.95***	-.85***	.18
7. GC							---	-.92***	1.00***	-.28
8. pS								---	-.92***	.23
9. pGC									---	-.29
10. BDI-II										---

Note. PI List 2 = Number of trials needed to reach the criterion at List 2 of the Proactive Interference task, RRS (10) = Ten-item version of the Ruminative Response Scale, RRS (B) = Brooding subscale of the Ruminative Response Scale, RRIQ = Ruminative subscale of the Responses to Intrusions Questionnaire, NI-RIQ = Negative Interpretations subscale of the Responses to Intrusions Questionnaire, S = number of Specific memories at the AMT, GC = number of General, Categorical memories at the AMT, pS = proportion of Specific memories at the AMT, pGC = proportion of General, Categorical memories at the AMT, BDI-II = Beck Depression Inventory – Second edition.

^a All reported correlations with PI List 2 are partial correlations, controlled for PI List 1.

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 4. *Pearson correlations between AMT-indices and resistance to proactive interference (PI List 2) after controlling for general learning ability (PI List 1) and for depressive symptoms (BDI-II).*

	Student sample ($N = 65$)	Patient sample ($N = 37$)
	PI List 2	PI List 2
S	-.11	-.45**
GC	.29*	.29
pS	-.25*	-.37*
pGC	.28*	.30

Note. PI List 2 = Number of trials needed to reach the criterion at List 2 of the Proactive Interference task, S = number of Specific memories at the AMT, GC = number of General, Categorical memories at the AMT, pS = proportion of Specific memories at the AMT, pGC = proportion of General, Categorical memories at the AMT.

* $p < .05$, ** $p < .01$

Table 5. *Means and standard deviations for the PI-task performance of participants' with versus without intrusive memories.*

PI index	Student sample (<i>N</i> = 65)		Patient sample (<i>N</i> = 37)	
	Intrusive memory in the past week?		Intrusive memory in the past week?	
	Yes	No	Yes	No
PI List 1	39.3 (3.9)	38.3 (3.1)	38.0 (2.0)	40.1 (4.6)
PI List 2	45.7 (5.3)	46.9 (7.9)	56.0 (11.3)	65.4 (16.3)

Note. PI List 1 = Number of trials needed to reach the criterion at List 1 of the Proactive Interference task,

PI List 2 = Number of trials needed to reach the criterion at List 2 of the Proactive Interference task.

Footnotes

1. These secondary diagnoses were adjustment disorder ($n = 8$), anxiety disorder ($n = 5$, including one patient with PTSD), complicated grief ($n = 2$), AD(H)D ($n = 2$), anorexia ($n = 1$), somatoform disorder ($n = 1$), impulse control disorder ($n = 1$), obsessive compulsive disorder ($n = 1$), gender identity disorder ($n = 1$), and addiction ($n = 1$). Some of the patients had a personality disorder (PD), more specifically borderline PD ($n = 3$), obsessive compulsive PD ($n = 2$), dependent PD ($n = 2$), or histrionic PD ($n = 1$).
2. Analyses on the whole sample (with exception of the four patients who failed to finish the PI-task and the one patient with manic symptoms), yielded comparable results.
3. These were different kinds of antidepressants, e.g., benzodiazepines ($n = 26$), selective serotonin reuptake inhibitors ($n = 20$), serotonin–norepinephrine reuptake inhibitors ($n = 7$), and tricyclic antidepressants ($n = 2$). Some patients ($n = 6$) took antipsychotics for their depression, but these patients did not have a psychotic disorder. Patients with psychotic symptoms were not invited to participate in the current study. All but five patients were taking a combination of different kinds of antidepressants.
4. No analyses were done with the number or proportion of extended memories, because research has demonstrated that rAMS in depression depends on categoric memories rather than extended memories (e.g., Williams & Dritschel, 1992; Goddard, Dritschel, & Burton, 1996).
5. For both samples, the correlations between RRS scores and the number of categoric memories on the AMT are also reported in a summary of studies failing to find significant associations between rumination and AMS (see Smets, Griffith, Wessel, Walschaerts, & Raes, 2013, Table 1, Studies 3 and 4).

6. We have also investigated the relationships of the other variables with depressive symptoms. Most of them were in the predicted direction, and can be found in Tables 2 and 3. In addition, independent samples t-tests were conducted to investigate whether participants with at least one intrusive memory in the week prior to the testing would have more depressive symptoms than participants without intrusive memories. This was indeed the case in the student sample, with significantly more depressive symptoms for those reporting at least one intrusive memory ($M = 13.7$; $SD = 1.5$) than those reporting no intrusive memories ($M = 8.5$; $SD = 0.9$), $t(52.180) = 2.94$, $p < .01$. In the patient sample, participants with at least one intrusive memory in the week prior to the testing had marginally significantly more depressive symptoms ($M = 35.6$; $SD = 2.0$) than those without intrusive memories ($M = 28.9$; $SD = 2.5$), $t(35) = 1.87$, $p = .069$.